

- 1) Discuss about the reasons for implementing a CAD system.
- 2) Write briefly on the secondary storage devices used in CAD System.
- 3) What is the need for concatenation of transformations? Explain what care should be taken in such cases.
- 4) Discuss about the applications of the NC system.
- 5) What is APT? Discuss its major statements with examples. Enlist any ten G-codes & M-codes.
- 6) Briefly explain about lean manufacturing.
- 7) Discuss the benefits & limitations of CAD CAM?
- 8) Briefly discuss the various geometric modeling capabilities?
- 9) Distinguish between wireframe & surface modeling?
- 10) What are the different DNC systems? Enumerate the main components of a NC machine tool?
- 11) What are the advantages of having a centralized database?
- 12) What are the functions of graphic software? Explain briefly
- 13) What are the types of CNC? State the functions of CNC?
- 14) Compare CNC with DNC? What are the advantages of combining CNC & DNC?
- 15) Describe the main features of the machine control unit?
- 16) How is CIM different from CAM? What are the benefits of CIM over that of CAM?
- 17) Write short notes on :
 - AGVs
 - Lean manufacturing
 - Robotics
 - Combined CNC/DNC
- 18) What are the important functions of the design workstation?
- 19) Explain the three types of coordinate systems used to input, store & display
- 20) model geometry & graphics.
- 21) Briefly discuss the data required for Computer Assisted Part Programming.
- 22) Explain the NC motion control system.
- 23) Describe the various database models which are generally used.
- 24) Define DNC & Explain in detail its different functions.
- 25) Discuss about the reasons for implementing a CAD system.

Q1) WHAT IS COMPUTER-AIDED DESIGN (CAD)?

Originating in the 1960s, CAD is a method of mocking up designs in 2D and 3D simulations. The 1990s gave rise to tools like CATIA and AutoCAD, making computer-aided design accessible to a variety of sectors. The most common professionals who leverage CAD include engineers, architects and construction workers.

CAD allows experts to create more accurate design representations. CAD replaced manual design drafting, allowing design development, alteration and optimization. CAD enables engineers to craft more precise designs and manipulate them virtually. CAD software calculates how multiple materials relate. This feature is particularly crucial as more specs are added by contractors.

CAD programs boast many features and have become foundational in construction, architecture and engineering sectors. CAD's advancement has changed these industries and all processes involved in implementing complex project phases.

HOW IS CAD IMPLEMENTED?

CAD often assumes electronic forms for print, machining and manufacturing. CAD is leveraged in several processes throughout a design's lifecycle. Here are few ways in which CAD is integrated into different professions:

- Architecture - Architecture is among the most complex disciplines when it comes to CAD. Many steps of architectural project design require software support. More established firms typically incorporate building information modeling (BIM) software such as Revit to improve productivity. Smaller companies may chain varying tools to serve a similar purpose.
- Product design - Industrial designers leverage CAD programs like Fusion 360, Inventor, or Solid Works to visualize components and predict and confirm their functionalities.
- Graphic design – Graphic designers also utilize 2D or 3D CAD software to visualize mockups. Graphic CAD software allows users to toggle effects, typography, shapes and backgrounds to facilitate artwork.
- Engineering – CAD programs used by engineers serve a wide array of purposes. Many common elements drafted using CAD include buildings, infrastructure components, circuits, telecommunications networks, mechanical items, medical devices, utilities and manufacturing parts.

Overall, professionals leverage CAD to design products, sketch blueprints, develop graphics and imagine new machinery.

INCREASES PRODUCTIVITY

CAD software enables developers to work more quickly, cut production costs and, ultimately, complete projects more quickly. Before, all developer sketches and designs were completed by hand. This process could easily take days to complete. Computer software empowers designers to seamlessly experiment with concepts and save drafts digitally.

Since CAD allows for more efficient designing, companies can maintain smaller teams. This benefit enables entities to create premium, affordable products and accelerate production while making product improvement more flexible.

REDUCES ERRORS

With manual design, errors typically arise while drafting bills of materials. One of the advantages of CAD is that this risk is nearly averted, as zero manual input is required once a drawing is made. Repetitive tasks like symbol placement and drawing storage are automated with CAD software. Also, these programs are typically designed to forecast and prevent common design mistakes.

A few ways CAD helps prevent mistakes include:

- Preventing Human Error – When professionals use CAD, the chance of human error is mitigated significantly. If someone inputs erroneous parameters, the software alerts them of these mistakes.
- Direct Design Transfer - After designing a product using CAD software, the user can transfer the computer model directly to manufacturing equipment. Since errors were averted while developing the component, the machinery can craft an item seamlessly, avoiding resource waste.
- Quick Prototyping – Prior to the invention of CAD, manual design was a slow process. After a design was drawn manually, a demo product needed to be tested. However, CAD gets ride of the need for physical prototyping, instead allowing the designer to simulate all necessary testing virtually in the program.
- Easy Alterations – Adjustments are often needed during production. Implementing manual changes typically yields some human error since product variable requires independent input. With CAD, engineers can change various views simultaneously corresponding to the first alteration.

IMPROVES QUALITY

CAD software allows designers to return to the drawing board in case of errors. Saved drafts and designs can be referenced easily to address any potential mistakes. Designers can predict errors before construction, allowing teams to prevent costly mistakes before they occur. This factor improves the quality of the design.

Additionally, CAD programs offer professionals a slew of design tools that allow the consideration of a variety of calculations. Low-risk, virtual investigating allows organizations to improve manufacturing speeds and reduce resource waste due to flawed designs.

ENABLES INFORMATION SHARING

CAD programs catalogue changes and design histories. CAD files can be shared with partners and reviewed with teams to double-check details. Cloud-based CAD systems allow remote workers to collaborate on projects and complete projects more quickly.

Overall, CAD fosters better communication by improving:

- Internal Information Sharing - 3D designs provide improved information on features to company leaders or managers, allowing better internal understandings of the vision and work required by the engineers. This variable helps supervisors establish achievable goals as they can accurately gauge the time and production required to execute a project.
- B2B Interfacing – CAD allows supply chain vendors to better communicate their requirements as 3D designs can be easily visualized, mitigating fit and tolerance issues.
- Assembly Line Interaction – As designs can be visualized and tested before manufacturing, team members on the ground are allotted information about vital design features like fillets, chambers or holes. 3D modeling accelerates development while reducing assembly errors.
- Customer Feedback - 3D models and visualizations also improve the customer experience, showcasing the product design more effectively.
- Marketing – Virtual designs may facilitate marketing a product, as a promotional team can visualize the design and useable functions, enabling advertising departments to better showcase product features to customer

Q2) What Does Secondary Storage Device Mean?

A secondary storage device refers to any non-volatile storage device that is internal or external to the computer. It can be any storage device beyond the primary storage that enables permanent data storage.

A secondary storage device is also known as an auxiliary storage device, backup storage device, tier 2 storage, or external storage.

Secondary storage allows for the storage of data ranging from a few megabytes to petabytes. These devices store virtually all programs and applications stored on a computer, including the operating system, device drivers, applications and general user data.

They are used for a variety of purposes ranging from backup data used for future restores or disaster recovery, long-term archiving of data that is not frequently accessed, and storage of non-critical data in lower-performing, less expensive drives.

The fundamental characteristics of secondary storage are high capacity and low cost, although speed, reliability and portability might also be important.

Longevity and long-term accessibility may also be an issue. For example, a lot of data from the previous decades that has been stored on magnetic tapes is now practically unusable.

Secondarily stored data might not be under the direct control of the operating system. For example, many organizations store their archival data or critical documents on secondary storage drives which cannot be accessed by their main network to ensure their preservation whenever a data breach occurs.

Since these drives do not interact directly with the main infrastructure and can be situated in a remote or secure site, it is unlikely that a hacker may access these drives unless they're physically stolen.

Most of the secondary storage devices used to be internal to the computer

such as the hard disk drive, the tape disk drive and even the optical storage drive (CD-ROM, Blu-ray, and DVD) and floppy disk drive.

However, today, many secondary storage drives are frequently external, especially since the introduction of USB flash drives and plug-and-play devices. Also, many secondary storage devices are now virtual devices residing on third-party cloud servers hosted by many services such as Dropbox, Google Drive, Amazon Web Services (AWS), or Microsoft Azure. Cloud repositories are particularly used by companies that embrace the software-as-a-service (SaaS) model.

Although many forms of backup storage such as tape drives and floppy diskettes have been long abandoned, secondary storage devices include:

- Solid-state drives (SSDs).
- Hard disk drives (HDDs).
- Cloud storage.

- CD-ROM drives.
- DVD drives.
- Blu-ray drives.
- USB flash drives.
- SD cards.
- Floppy diskette.
- Tape drives.
- Zip and Jaz drives.

Q3) What is the need for concatenation of transformations?

(31) CONCATENATION

The single transformations can be combined as a sequence of transformations. This is called concatenation & the combined transformations are called concatenated transformations.

Scaling:- Scaling of an element is used to enlarge it or reduce its size.

Ex:- The points of an element can be scaled by the scaling matrix as follows:-

$$(x', y') = (x, y) \cdot S$$

where $S = \begin{bmatrix} m & 0 \\ 0 & n \end{bmatrix}$ - the scaling matrix

- This would produce an alteration in the size of the element by a factor m in the x dirⁿ and by a factor n in the y dirⁿ.

Rotation:- In this transformation, the points of an object are rotated about the origin by an angle θ .

- For a +ve angle, this rotation is in the counterclockwise direction. This accomplishes rotation of the object by the same angle but it also moves the object.
- In matrix notation,

$$(x', y') = (x, y) R$$

where $R = \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix}$ - the rotation matrix

(32)

(2) Defining the graphic elements

- The user has a variety of different ways to call a particular graphic element and position it on the geometric model.
- Ex:- A point could be defined as by its x, y, z Coordinates.

(3) Editing the geometry

- CAD System provides editing capabilities to make corrections and adjustments in the geometric model.
- When developing the model, the user must be able to delete, move, copy and rotate components of the model.
- The editing procedure involves selecting the desired portion of the model and executing the appropriate command.
- The method of selecting the segment of the model to be modified varies from system to system.

TRANSFORMATIONS1) Two-dimensional transformations

- To locate a point in a two-axis Cartesian system, the x and y coordinates are specified.
 - These coordinates can be treated together as a 1×2 matrix (x, y) .
- Ex:- the matrix $(2, 5)$ would be interpreted to be a point which is 2 units from the origin in the x -dirⁿ & 5 units from the origin in the y -direction.

Translation

$$x' = x + m, \quad y' = y + n$$

where $x', y' \rightarrow$ Coordinates of the translated point

$x, y \rightarrow$ Coordinates of the original point

$m, n \rightarrow$ movements in the x and y directions.

In matrix notation, it can be represented as

$$(x', y') = (x, y) + T$$

where $T = (m, n)$ the translation matrix.

Q4) Discuss about the applications of the NC system.

(48)

Where NC should be used:-

- (1) Parts are produced frequently and in small lots size. (1)
- (2) The part geometry is complex. (2)
- (3) Many operations must be performed on the part in processing. (3)
- (4) Much metal needs to be removed.
- (5) Engineering design changes are likely.
- (6) Close tolerances must be held on the workpart.
- (7) The parts require 100% inspection.
- (8) It is an expensive part where mistakes in processing would be costly.

Advantages of NC.

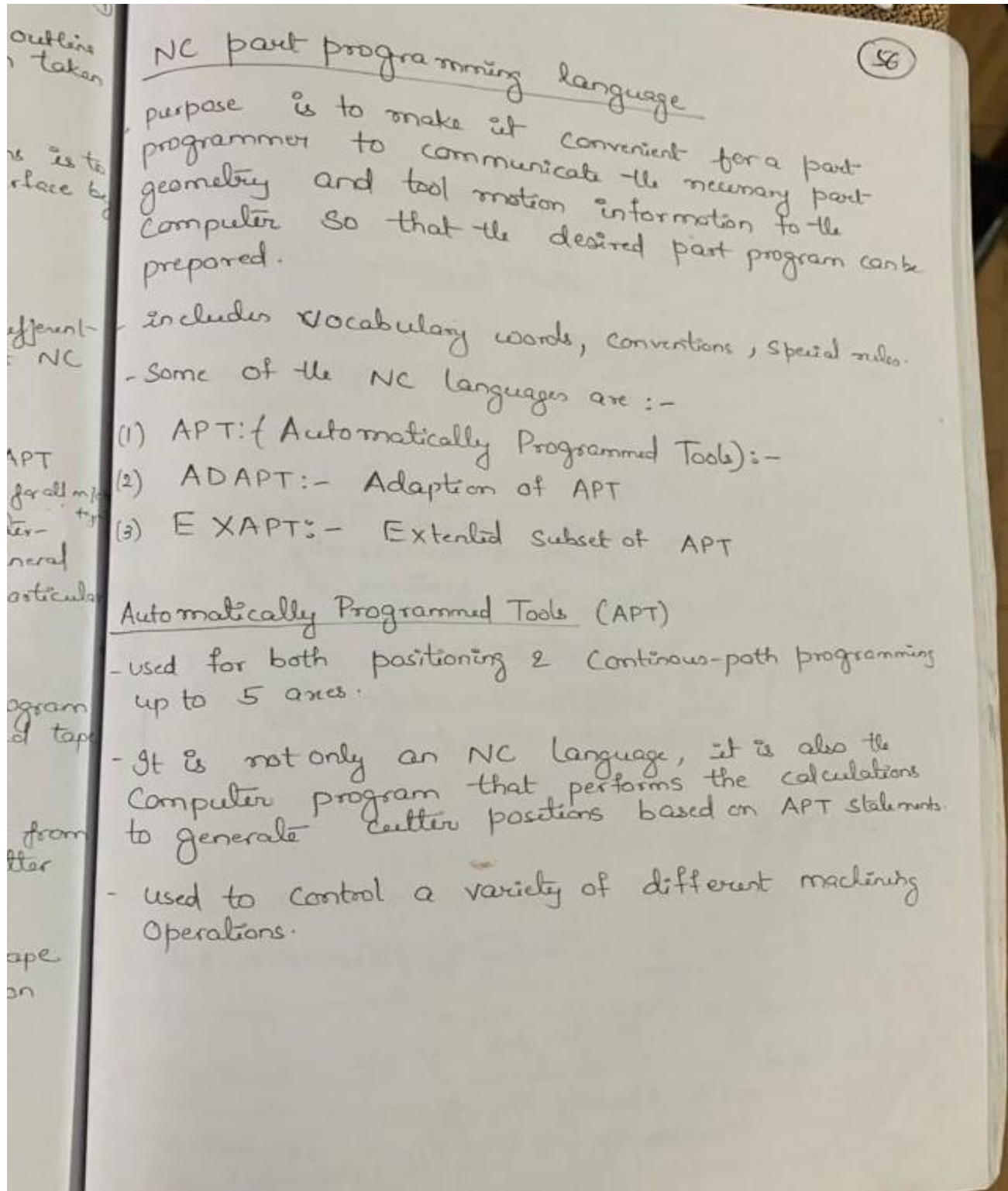
- (1) Reduced non-productive time:- Fewer setups, less time in setting up, reduced workpiece handling time, automatic tool changes on some machines, etc.
- (2) Reduced fixturing:-
NC requires fixtures which are simpler and less costly to fabricate because the positioning is done.
- (3) Greater manufacturing flexibility:-
With NC, it is easy to adapt to engg. design changes, alterations of the production schedule, etc.
- (4) Improved quality control:-
NC produces parts with greater accuracy, reduced scrap, & lower inspection requirements.
- (5) Reduced inventory:- Owing to fewer setups & shorter lead times, with NC, the amount of inventory is reduced.
- (6) Reduced floor space requirements:-
Since one NC machining center can do the production of several conventional machines, the amount of floor space required is less than in a conventional shop.

DISADVANTAGES OF NC

(49)

- (1) Higher Investment cost
- (2) Higher maintenance cost-
- (3) Training NC personnel:- (Requires higher skill level than conventional operations)

Q5) What is APT?



(57)

There are four types of statements in the APT language:-

(1) Geometry statements:-

- These define the geometric elements that comprise the workpart.
- They are also called 'definition statements'.

(2) Motion statements:-

These are used to describe the path taken by the cutting tool.

(3) Postprocessor statements:-

These apply to the specific m/c tool & control system. They are used to specify feeds & speeds and to activate other features of the m/c.

(4) Auxiliary statements:-

These are miscellaneous statements used to identify the part, tool, tolerances & so on.

GEOMETRY STATEMENTS

- The general form of an APT geometry statement is

Symbol = geometry type/descriptive data

Ex:- P1 = POINT/5.0, 4.0, 0.0

- The statement is made up of three sections. The 1st section is the symbol used to identify the geometric element.
- Symbol (Combination of 6 or fewer alphabetic & numeric characters)

Q6) Briefly explain about lean manufacturing.

Lean manufacturing is a production process based on an ideology of maximising productivity while simultaneously minimising waste within a manufacturing operation. The lean principle sees waste is anything that doesn't add value that the customers are willing to pay for.

What are the Principles of Lean Manufacturing ?

According to Womack and Jones, there are five key lean principles: value, value stream, flow, pull, and perfection.

1. Value

Value is always defined by the customer's needs for a specific product. For example:

- What is the timeline for manufacturing and delivery?
- What is the price point?
- What are other important requirements or expectations that must be met?

This information is vital for defining value.

2. Value stream

Once the value (end goal) has been determined, the next step is mapping the "value stream." This includes all the steps and processes involved in taking a specific product from raw materials and delivering the final product to the customer.

Value-stream mapping is a simple but eye-opening experience that identifies all the actions that take a product or service through any process—design, production, procurement, HR, administration, delivery, or customer service. The idea is to draw a "map" of the flow of material/product through the process, with a goal of identifying every step that does not create value and then finding ways to eliminate those wasteful steps.

Value-stream mapping is sometimes referred to as process re-engineering. Ultimately, this exercise also results in a better understanding of the entire business operation.

3. Flow

After the waste has been removed from the value stream, the next step is to be sure the remaining steps flow smoothly with no interruptions, delays, or bottlenecks. In the words of LEI: "Make the value-creating steps occur in tight sequence so that the product or service will flow smoothly toward the customer."

This may require breaking down silo thinking and making the effort to become cross-functional across all departments, which can be one of the greatest challenges for lean programs to overcome.

However, studies show that this will also lead to huge gains in productivity and efficiency—sometimes as high as 50% improvement or more.

4. Pull

With improved flow, time to market (or time to customer) can be dramatically improved. This makes it much easier to deliver products as needed, as it means the customer can “pull” the product from you as needed (often in weeks, instead of months).

As a result, products don’t need to be built in advance or materials stockpiled. This reduces the need for an expensive inventory that needs to be managed, saving money for both the manufacturer/provider and the customer.

5. Perfection

Accomplishing steps 1-4 is a great start, but the fifth step is perhaps the most important: making lean thinking and process improvement part of your corporate culture. Every employee should be involved in implementing lean.

As gains continue to pile up, it is important to remember that lean is not a static system and requires constant effort and vigilance to perfect. Lean experts often say that a process is not truly lean until it has been through value-stream mapping at least half a dozen times.

Advantages of Lean Manufacturing

1. Waste Minimization

Lean manufacturing can efficiently minimize waste within a production facility. This is arguably the most significant benefit of lean manufacturing. Waste is defined by any activity that does not add value to the process. Common waste areas include: motion, inventory, waiting, overproduction, defects, transportation, and over-processing. As companies sit on large amounts of inventory and waste, this process eliminates outdated or aged inventory. In addition, this process reduces the costs within the operation.

2. Enhanced Customer Relationships

Lean focuses on loyal customers' concerns and suggestions to cut some wasteful processes. Rather than focusing on the needs of all customers, companies are able to focus on their loyal customers to build strong and reliable relationship. This way, your customer interactions will improve and the relationships with your trusted customers will offer a steady flow of revenue coming in.

3. Lean Infrastructure

A lean infrastructure means that you are only dealing with a few components: building, tools, supplies, equipment, and labor to fulfill near-term inventory demand. The facility does not waste space within the operation and enables the facility to come as close as it can to production efficiency.

Disadvantages of Lean Manufacturing

1. Equipment Failure

Lean has very little room for error. Equipment or labor failure can lead to major inconsistencies and can make the entire operation fall behind. In other mass production facilities, employees could move from one machine to another in the event of a breakdown. In lean, there are not many other places for employees to move to because everything within the operation is being utilized. In addition, the breakdown of a machine must be fixed immediately as there are usually no alternative resources that can do the work. This is why it is important to stay on top of all machine maintenance and inspections.

2. Delivery Inconsistencies

In correlation with equipment failure, lean manufacturing can lead to delivery inconsistencies. Using lean techniques means that you have a smaller error margin. If your supply deliveries are late, you may not have enough raw materials to meet your customer demands, leading to late deliveries. This disadvantage can hinder customer relationships, push customers towards your competitors, and cost you revenue.

3. Employee Dissatisfaction

Adopting lean manufacturing processes requires change among employees to more efficient production processes to ensure that quality products are being made. This can be risky if employees reject the new methods. Having good managers that can help support and persuade the change from one technique to another can be helpful.

Q7) Discuss the benefits & limitations of CAD/CAM?

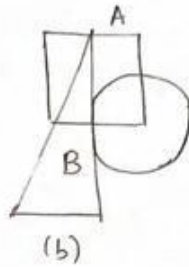
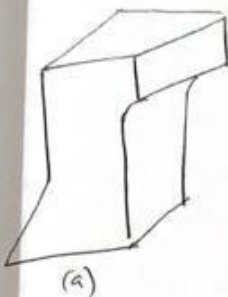
Advantages of CAD	Disadvantages of CAD
Ideas can be drawn and developed quickly	Expensive to set up
Designs can be viewed from all angles and with a range of materials	Needs a skilled workforce
Some testing and consumer feedback	Difficult to keep up with constantly

Advantages of CAD	Disadvantages of CAD
can be done before costly production takes place	changing and improving technology
It becomes easier to design and test a range of ideas	Computers can fail

Advantages of CAM	Disadvantages of CAM
Fast and accurate production	Expensive to set up
Machines can run constantly on repetitive tasks	Needs a skilled workforce of engineers
Good for producing on a mass/flow production line	Downtime required for maintenance
Less material wastage	Computers and machines can fail

Q8) Briefly discuss the various geometric modeling capabilities

(34)



- The solid model in part (a) of the figure is formed by the intersection of the complement of the cylinder C with the union of rectangular solid A and triangular prism B.

$$\overline{C}(A+B)$$

- Part (b) of the figure shows the three elements A, B & C in cross-sectional view.

WIRE-FRAME VERSUS SOLID MODELING

- In the construction of the wire-frame model, the edges of the objects are shown as lines.
- For objects in which there are curved surfaces, contour lines can be added, to indicate the contour.
- The image assumes the appearance of a frame constructed out of wire - hence the name 'Wire frame' model.
- Wire-frame models are quite adequate for 2-dimensional representation.
- Many 3-dimensional wire-frame systems do not possess an automatic hidden-line removal feature. Consequently, the lines that indicate the edges at the rear of the model is seen, which can cause the image to be somewhat confusing to the viewer.
- Another limitation:- CAD systems define the model in their databases. Ex:- There may be doubt in case of a surface definition as to which side of the surface is solid.

(35)

Solid models

- An improvement over wire-frame models → is the solid modelling approach.
- In this approach, the models are displayed as solid to the viewer, with very little risk of misinterpretation.
- When colour is added to the image, the resulting picture becomes strikingly realistic.
- Applications:- Colour illustrations in magazines & technical publications, animation in movie films & training simulators.
- There are two factors which promote widespread use of solid modelers. The first is the increasing awareness among users of the limitations of wire-frame systems.
- The 2nd reason is the continuing development of computer hardware & software which make solid modelling possible.
- Solid modelers require a great deal of computational power in terms of both speed & memory, in order to operate.
- Two basic approaches to the problem of solid modeling have been developed:
 - (1) Constructive solid geometry (CSG), also called the building block approach.
 - (2) Boundary representation (B-rep)

CSG Systems:- allow the user to build the model out of solid graphic primitives, such as rectangular blocks, cubes, spheres, cylinders.

(36)

The boundary representation approach requires the user to draw the outline or boundary of the object on CRT screen.

The user would sketch the various views of the object, drawing interconnecting lines among the views to establish their relationship.

The two approaches have their relative advantages & disadvantages.

The CSG systems have a significant procedural advantage in the initial formulation of the model.

It is relatively easy to construct a precise solid model out of regular solid primitives by adding, subtracting, and intersecting the components.

B-rep systems become evident when unusual shapes are encountered that is not included in CSG systems.

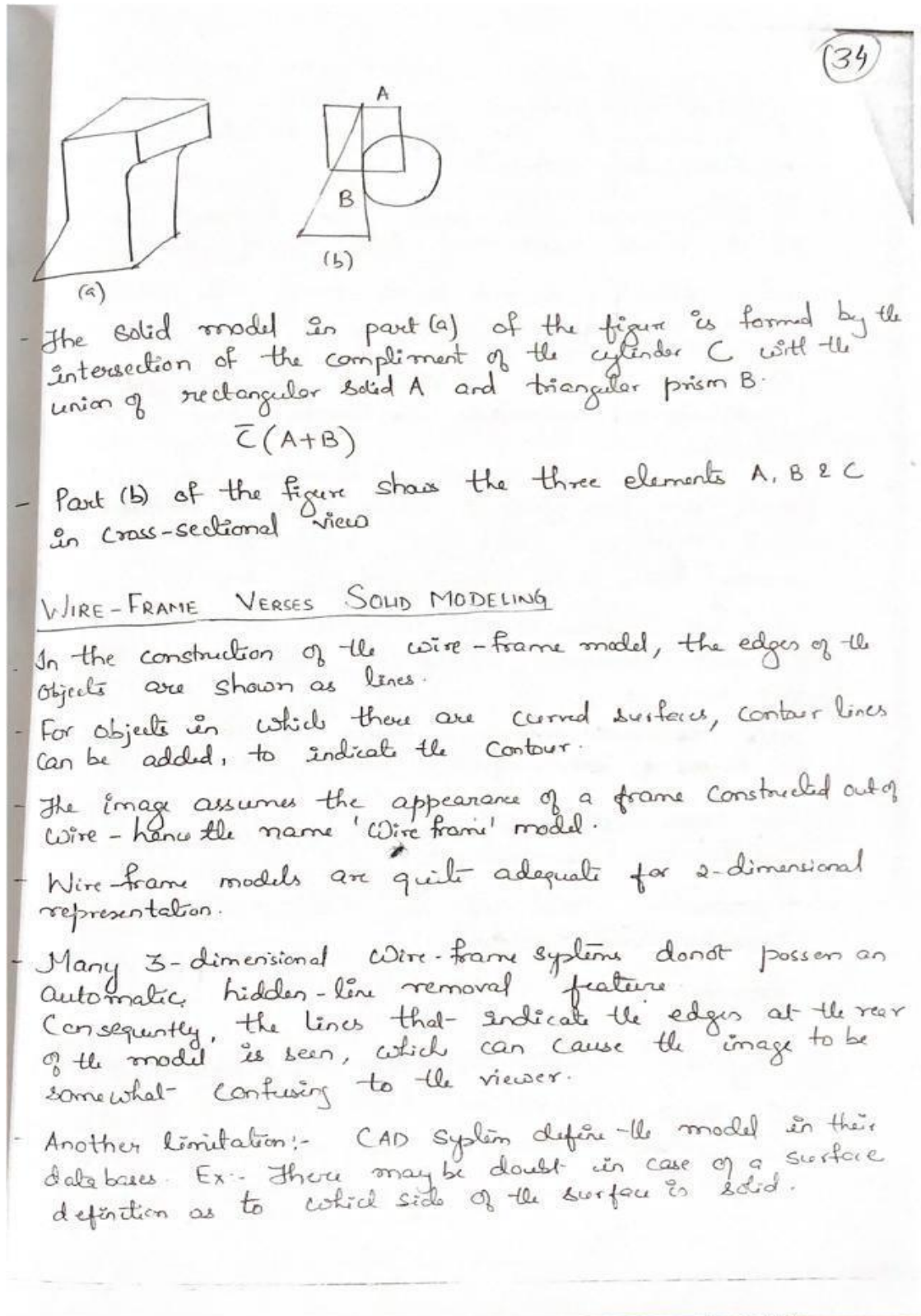
Ex. Wing shapes

Another point of comparison betⁿ the two approaches is the diffⁿ in the way the model is stored in the database for the two systems.

The CSG system generally requires less storage, but more computation to reproduce the model & its image. However, B-rep system requires more storage space but less computation effort to reproduce the image.

A related benefit of B-rep systems is that it is relatively simple to convert back & forth betⁿ a boundary representation and a corresponding wire-frame model.

Q9) Distinguish between wireframe & surface modeling ?



Q10) What are the different DNC systems?

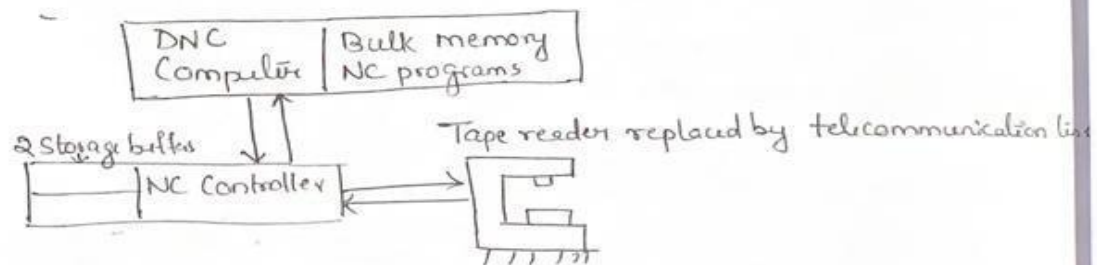
(78)

- Sometimes, it is necessary to use satellite computers. These satellites are mini-computers and they take some of the burden off the central computer.
- Each satellite controls several machines. Groups of part program instructions are received from the Central Computer and stored in buffers. They are then dispensed to the individual machines as required.
- Feedback data from the machines are also stored in the Satellite's buffer before being collected at the Central Computer.

Two types of DNC

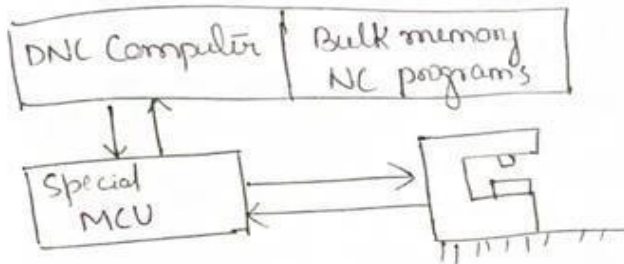
- (1) BEHIND-THE-TAPE-READER (BTR) System
- (2) SPECIALIZED MACHINE CONTROL UNIT

(1) BTR System:-



- The connection ^{with} the computer is made betⁿ the tape reader and the controller unit - behind the tape reader.
- The controller unit uses two temporary buffers to receive blocks of instructions from the DNC computer and convert them into m/c actions.
- While one buffer is receiving a block of data, the other providing control instructions to the m/c tool.

(79)

Special m/c Control unitDNC with special MCU

- The other strategy in DNC is to eliminate the regular NC controller and replace it with a special MCU.
 - This special MCU is a device that is specifically designed to facilitate communication between the m/c tool and the computer.
 - The special MCU configuration achieves a superior balance between accuracy of the interpolation and fast metal removal rates than is generally possible with the BTR system.
 - The special MCU is soft-wired, while the conventional NC controller is hard-wired.
- The advantage of soft-wiring is its flexibility. Its control functions can be altered with relative ease to make improvements. It is much more difficult to make changes in the regular NC controller because rewiring is required.
- BTR Cost is less, since only minor changes are needed in the conventional NC system to bring DNC into the shop.
 - BTR Systems do not require the replacement of the Conventional Control unit by a Special MCU.

Q11) Enumerate the main components of a NC machine tool?

(38)

Chapter 4
CAM - NUMERICAL CONTROL

Numerical Control :- defined as a form of programmed automation in which the process is controlled by numerical letters and symbols.

- In NC, a program of instructions is designed for particular job. When the job changes, the program of instructions is changed.
- This capability to change the program for new job gives flexibility to NC.
- NC technology has been applied to a wide variety of operations (e.g. inspection, sheet metal press working, welding). But principal applications in metal machining processes.

Basic Components of an NC System

- (1) Program of instructions
- (2) Controller unit, (Machine Control Unit, MCU)
- (3) M/C tool or other controlled process

- The program of instructions serves as input to the Controller unit, which in turn commands the machine tool or other process to be controlled.

Program of instructions :-

- The program of instructions is the detailed step-by-step set of directions, which tells m/c tool what to do.
- It is coded in numerical/symbolic form on some type of input medium (Punched cards, magnetic tape) that can be interpreted by the controller unit.
- There are two other methods of input to the NC system.

(39)

- The first is by manual entry of instructional data to the controller unit. This method is called manual data input, abbreviated MDI. This is appropriate only for relatively simple jobs where the order will not be repeated.
- The second other method of input is by means of a direct link with a computer. This is called direct numerical control or DNC.
- The program of instructions is prepared by Post-processor. The programmer's job is to provide a set of detailed instructions by which the sequence of processing steps is to be performed. For the machining operation, the processing steps involve the relative movement betⁿ the cutting tool & the w/p.

Controller unit

- The second basic component of the NC system is the Controller unit.
- It consists of the electronics and hardware that read and interpret the program of instructions and convert it into mechanical actions of the machine tool.
- The typical elements of a conventional NC Controller unit include the tape reader, a data buffer, signal output channels to the m/c tool, feedback channels from the m/c tool and sequence controls to coordinate the overall operation of the foregoing elements.

Tape reader:- is an electromechanical device for winding and reading the punched tape containing the program of instructions.

- The data contained on the tape are read into the data buffer.

(40)

Data buffer:- The purpose of data buffer is to store the input instructions in logical blocks of information. (A block of information represents one complete step in the sequence of processing elements) Ex:- A block may be the data required to move the m/c table to a certain position & drill a hole at that location)

Signal output channels:- are connected to the servomotors and other controls in the m/c tool. Through these channels the instructions are sent to the m/c tool from the Controller unit.

Feedback channels:- To make certain that the instructions are sent to the m/c tool from the Controller are properly executed by the m/c, feedback data are sent back to the Controller via the feedback channels.

- The most important function of this return loop is to assure that the table and workpart have been properly located w.r.t the tool.

Sequence controls:- It coordinates the activities of the other elements of the Controller unit.

- The tape reader is actuated to read data into the buffer from the tape, signals are sent to & from the m/c tool and so on. These types of operations must be synchronized and this is the function of the sequence controls.

Control panel:- contains the dials and switches by which m/c operator runs the NC system. It may also contain data displays to provide information to the operator.

(41)

Although the NC System is an automatic system, the human operator is still needed to turn the m/c on and off, to change tools, to load & unload the m/c and to perform various other duties.

M/c tool or other controlled process

The 3rd basic component of an NC System is the m/c tool or other controlled process.

It is the part of the NC system which performs useful work.

The m/c tool consists of the worktable and spindle, motors and controls necessary to drive them.

It also includes cutting tools, work fixtures and other auxiliary equipment needed in the machining operation.

The NC procedure :-

1) Process planning :-

- It is concerned with the preparation of a route sheet. The route sheet is a listing of the sequence of operations which must be performed on the workpart.
- It also lists the machines through which the part must be routed in order to accomplish the sequence of operations.

2) Part programming :-

- A part programmer plans the process for the portions of the job to be accomplished by NC.
- They plan the sequence of machining steps to be performed by NC.

Q12) What are the advantages of having a centralized database ?

(33)

Data base structure

- The CAD data-base contains the application models, drawings, assemblies, etc.
- The data base resides in computer memory (primary & secondary storage).

The basic ingredients of the application model :-

- (1) Basic graphic elements (points & other elements)
- (2) Geometry (shape) of the model components & their location in space.
- (3) Topology or structure of the models - how the various components are connected to form the model.
- (4) Application-specific data, such as material properties.
- (5) Application-specific analysis programs, such as finite-element analysis programs.

- The list represents a building-block approach to model formulation. The model structure consists of both data and procedures to connect, describe and analyze the model.

- One possible data structure involves storing the coordinates of geometry, together with other information which might be required to completely define the model.

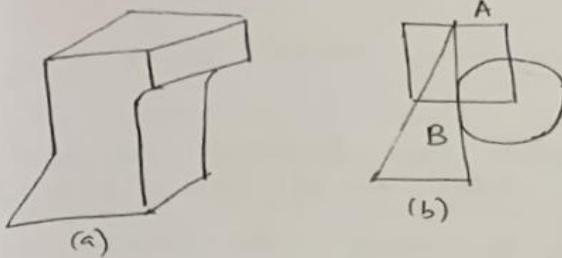
There are disadvantages to this type of data structure.

Ex:- Let us consider a cylinder. It consists of a line segment parallel to the y-axis & rotated about that axis to form a cylinder. (We require line segment (points) & axis of rotation)

→ We have to find solid cylinder.

- Boolean operations can be used to construct the geometric model.

(34)



- The solid model in part (a) of the figure is formed by the intersection of the complement of the cylinder C with the union of rectangular solid A and triangular prism B .

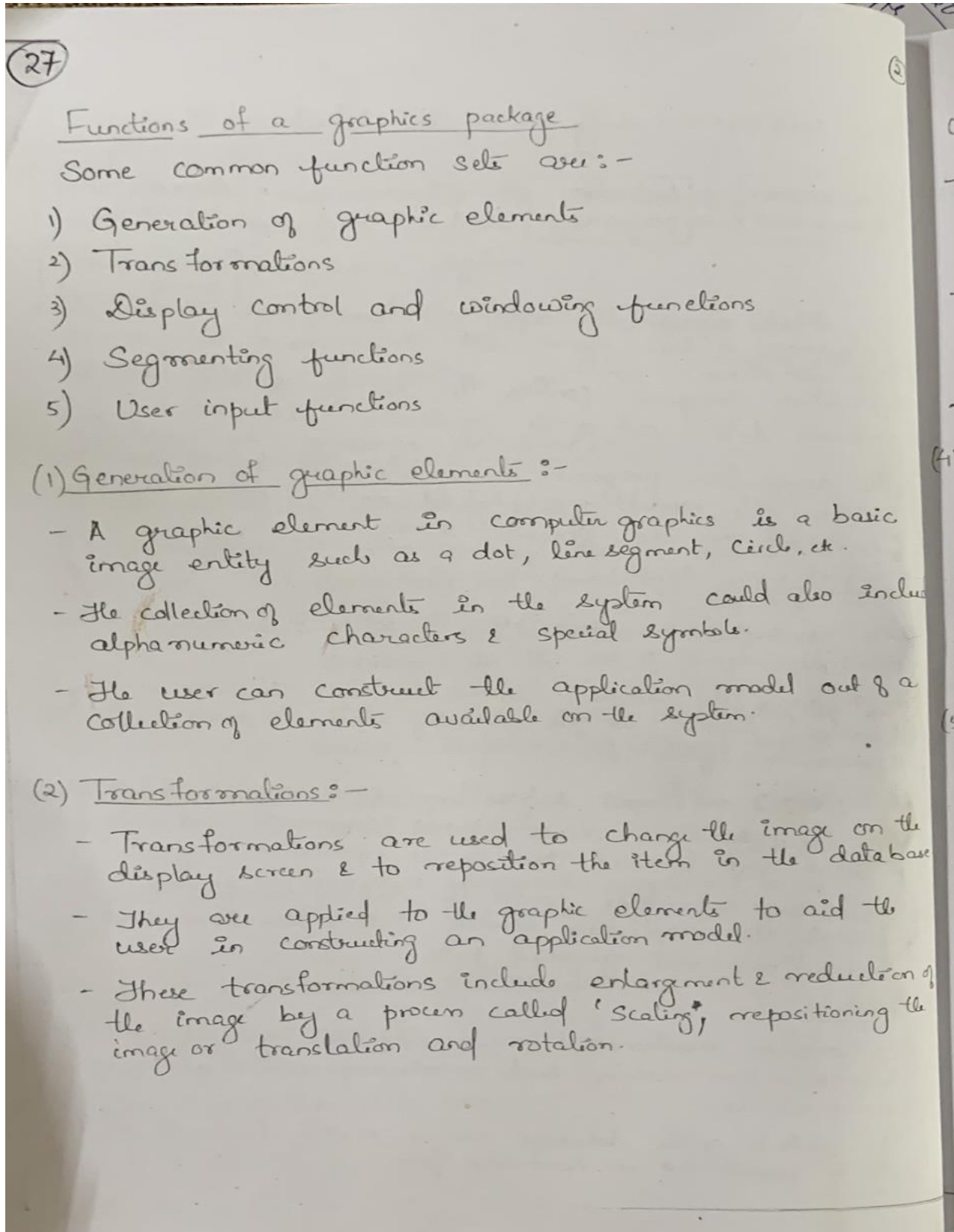
$$\overline{C}(A+B)$$

- Part (b) of the figure shows the three elements A , B & C in cross-sectional view.

WIRE-FRAME VERSUS SOLID MODELING

- In the construction of the wire-frame model, the edges of the objects are shown as lines.
- For objects in which there are curved surfaces, contour lines can be added, to indicate the contour.
- The image assumes the appearance of a frame constructed out of wire - hence the name 'Wire frame' model.
- Wire-frame models are quite adequate for 2-dimensional representation.
- Many 3-dimensional wire-frame systems do not possess an automatic hidden-line removal feature. Consequently, the lines that indicate the edges at the rear of the model are seen, which can cause the image to be somewhat confusing to the viewer.
- Another limitation:- CAD systems define the model in their databases. Ex:- There may be doubt in case of a surface definition as to which side of the surface is solid.

Q13) What are the functions of graphic software? Explain briefly



(28)

(3) Display control and windowing functions

- It provides the user with the ability to view the image from the desired angle and at the desired magnification.
- This is sometimes referred to as windowing because the graphics screen is like a window being used to observe the graphics model.
- Another aspect of display control is hidden-line removal.

(4) Segmenting functions

- It provide users with the capability to selectively replace, delete or otherwise modify portions of the image.
- The term 'segment' refers to a particular portion of the image which has been identified for purposes of modifying it.

(5) User input functions

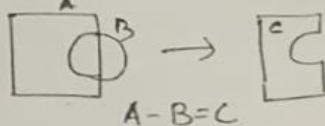
- They permit the operator to enter commands or data to the system.
- The entry is done by means of operator input devices.

Constructing the geometry

(1) The use of graphics elements

- These elements are called by the user during the construction process and added one by one to create the model.
- The graphics elements can be subtracted as well as added.

Ex:-



Q14) What are the types of CNC? State the functions of CNC?

(69)

Chapter-6 MODULE-4
Computer Controls in NC (3 types)

- ① Computer numerical control (CNC)
- ② Direct numerical control (DNC)
- ③ Adaptive Control

CNC involves the replacement of the conventional hard-wired NC Controller unit by a small computer (micro-computer).

The micro-computer performs some or all of the basic NC functions by programs stored in its read/write memory.

1 Computer is used to control 1 m/c tool.

(DNC uses a larger computer to control a no. of separate NC m/c tools.)

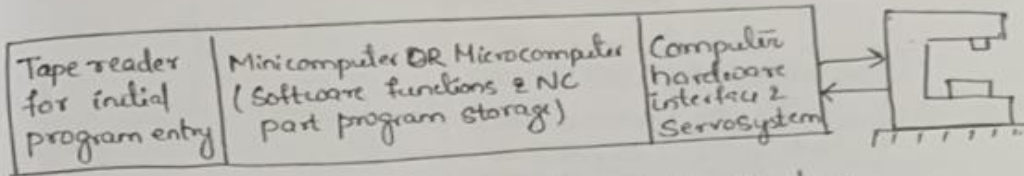
Adaptive Control:- doesnot require a digital computer for implementation.

- Control system that measures one or more process variables (cutting force, temp, horsepower, etc) & manipulates feed or speed.
- Objective is to optimize the machining process,

Problems with Conventional NC

- ① Part programming mistakes

In preparing the punched tape, part programming mistakes are common.



General Configuration of CNC System

Functions of CNC

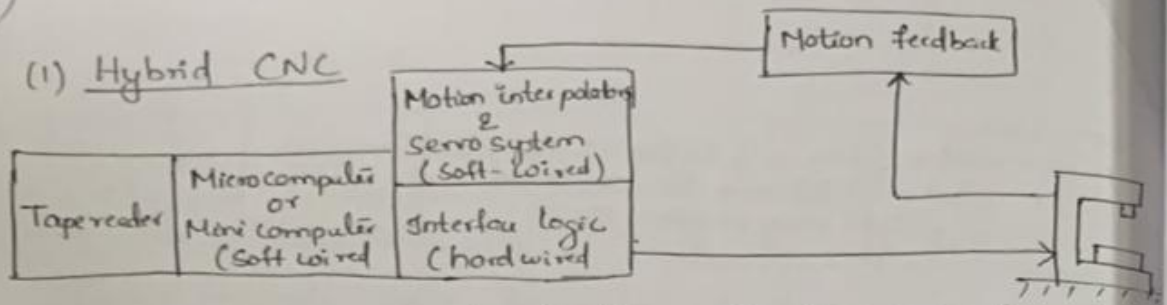
- (1) M/c tool control
- (2) In-process compensation
- (3) Improved programming & operating features
- (4) Diagnostics

M/c tool Control :-

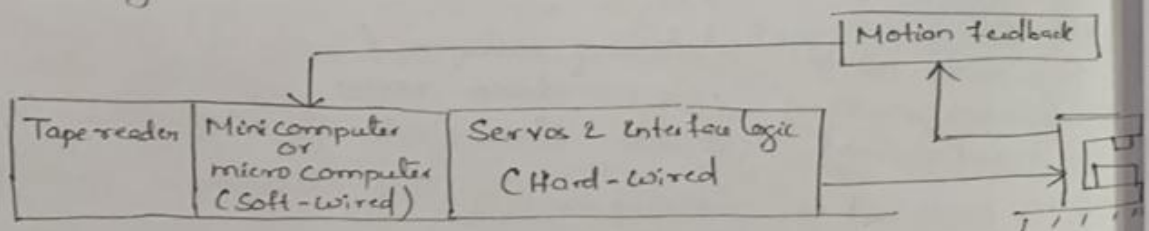
- The primary function of the CNC System is control of the m/c tool. It involves conversion of the part program instructions into m/c tool motions through the Computer interface and Servosystem.
- Main advantage of CNC :- to conveniently incorporate a variety of control features into the soft-wired controller unit.
- Some of the control functions (such as circular interpolation) can be done more efficiently with hard-wired circuits than with the Computer.
- This led to development of two alternative controller designs in CNC:

- (1) Hybrid CNC
- (2) Straight CNC

(74)

(1) Hybrid CNC

- The controller consists of the soft-wired & hard-wired logic circuits.
- The hard-wired components perform those functions, which they do best (feed rate generation, circular interpolation).
- The computer performs the remaining control functions and other duties, not normally associated with a conventional hard-wired controller.
- Certain NC functions can be performed more efficiently with the hard-wired circuits. Therefore, the circuits that perform these functions can be produced in large quantities at relatively low cost. Hence, a less expensive computer is required in the hybrid CNC Controller.

Straight CNC:-

- The Straight CNC System uses a computer to perform all the NC functions. The only hard-wired elements are those required to interface the computer with the machine tool & operator's console.
- Interpolation, tool position feedback and all other functions are performed by computer software.

75

- The advantage gained in Straight CNC is additional flexibility.

IN-PROCESS COMPENSATION

- A funⁿ closely related to m/c tool control is in-process compensation.

- Ex. - Adaptive Control adjustments to speed/ feed.
- Adjustment for errors sensed by in-process inspection probes & gauges.

IMPROVED PROGRAMMING AND OPERATING FEATURES

- The flexibility of soft-wired control has led to many convenient programming & operating features, such as:
 - (1) Editing the part programs at the m/c.
 - (2) Manual data input (MDI).
 - (3) Local storage of more than one part program.
 - (4) Graphic display of tool path.

DIAGNOSTICS

- NC m/c tools are complex & expensive systems. The complexity increases the risk of component failures which lead to system downtime.
- CNC machines are equipped with a diagnostics capability to assist in maintaining & repairing the system.

Q15) Compare CNC with DNC? What are the advantages of combining CNC & DNC?

Difference between CNC and DNC :

- 1) CNC stands for computer numerical control, DNC stands for direct numerical control.
- 2) In CNC, far off controlling of the operation is not possible, while in DNC facilitate far-flung control.
- 3) CNC is transferring machine instruction, DNC controls the information distribution to a wide variety of machines.
- 4) CNC is a vital section of the machine, DNC is not crucial to machines, DNC pc can come across at a distance from devices.
- 5) In the CNC program feeds directly into the computer by a small keyboard similar to our traditional keyboard, while in DNC part program is feed to the machine through the main computer.
- 6) Using CNC PC manipulates one NC machine, Using the DNC programmer can manage more than one NC laptop as required.
- 7) CNC is a feedback system, while DNC did not remove the tape.
- 8) CNC has low processing power when compared to DNC, DNC has high processing energy when compared to CNC.
- 9) CNC software is to enlarge the capacity of the precise computing device tool, while DNC now not only controls the equipment, also serves as a part of the administration statistics system.
- 10) In CNC we can modify the program in the computer, while in DNC order to modify a single computer is used.
- 11) CNC cost is high, while in DNC control more than 100 CNC machines at a time.
- 12) In CNC machine accuracy is high, while in DNC two way communication by telecommunication line.
- 13) CNC machine maintenance is high, Maintenance is low in DNC machines.

Q16) Difference between NC and CNC:

- 1) NC stands for numerical control while in the CNC called for computer numerical control.
- 2) In the NC machine, the operational parameter can not be altered, while in a CNC machine, we can alter the operational parameters.
- 3) The accuracy and flexibility of the CNC control are higher than the NC controls.
- 4) CNC machines are costly and require more maintenance cost as compared to the NC machines.
- 5) The NC machine, the instruction are given to the machine through punched cards, while CNC uses the computer for giving the input to the machine.
- 6) In NC machine modification in the program is difficult, while in CNC machine modification in the program is very easy.
- 7) The NC programs can only be modified by changing the information in the punched card, While CNC programs can be changed directly from the computer.

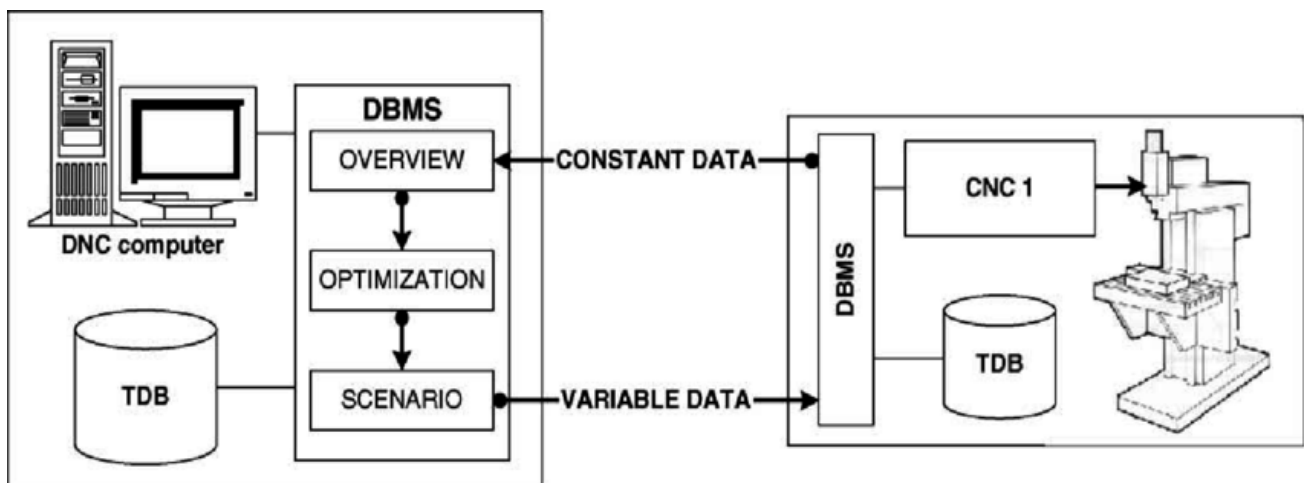
8) NC machine required more time and expert operators for developing the products, on the other hand, CNC is fast and more automated and does not require much manual work.

9) Except for punched cards, there is no other mechanism is available in the NC for the storage of the information, While in CNC uses computer chips for memory storage.

10) The programs in the NC machine cannot be stored, In CNC machines, the program is stored on the computer and can be used again and again.

11) In NC machine is not possible to run it continuously, while in CNC machine can be run continuously for 24 hours of a day.

Q17) What is combined CNC and DNC?



The combination of DNC and CNC provides the opportunity to add new capabilities and refine existing capabilities in these computerized manufacturing systems. The elimination of the use of punched tape as the input media for CNC machines. The DNC computer downloads the program directly to the CNC computer memory.

Q18) Describe the main features of the machine control unit?

(39)

The first is by manual entry of instructional data to the controller unit. This method is called manual data input, abbreviated MDI. This is appropriate only for relatively simple jobs where the order will not be repeated.

The second other method of input is by means of a direct link with a computer. This is called direct numerical control or DNC.

The program of instructions is prepared by Post-programmer. The programmer's job is to provide a set of detailed instructions by which the sequence of processing steps is to be performed. For the machining operation, the processing steps involve the relative movement betⁿ the cutting tool & the w/p.

Controller unit

- The second basic component of the NC system is the Controller unit.
- It consists of the electronics and hardware that read and interpret the program of instructions and convert it into mechanical actions of the machine tool.
- The typical elements of a conventional NC Controller unit include the tape reader, a data buffer, signal output channels to the m/c tool, feedback channels from the m/c tool and sequence controls to coordinate the overall operation of the foregoing elements.

Tape reader:- is an electromechanical device for winding and reading the punched tape containing the program of instructions.

- The data contained on the tape are read into the data buffer.

(40)

Data buffer:- The purpose of data buffer is to store the input instructions in logical blocks of information.

(A block of information represents one complete step in the sequence of processing elements) Ex:- A block may be the data required to move the m/c table to a certain position & drill a hole at that location)

Signal output channels:- are connected to the servomotors and other controls in the m/c tool. Through these channels the instructions are sent to the m/c tool from the Controller unit.

Feedback channels:- To make certain that the instructions are sent to the m/c tool from the hardware Controller are properly executed by the m/c, feedback data are sent back to the Controller via the feedback channels.

- The most important function of this return loop is to assure that the table and workpart have been properly located w.r.t the tool.

Sequence controls:- It coordinates the activities of the other elements of the Controller unit.

- The tape reader is actuated to read data into the buffer from the tape, signals are sent to & from the m/c tool and so on. These types of operations must be synchronized and this is the function of the sequence controls.

Control panel:- Contains the dials and switches by which m/c operator runs the NC system.

- It may also contain data displays to provide information to the operator.

Q19) What is the difference between CAD/CAM AND CIM

CAD/CAM involves the use of computers to make Design and Manufacturing more profitable.

- Parts of CIM use CAD/CAM techniques and products to try and make the factory fully connected using computers.
- The essential difference is CAD/CAM provides the tools, CIM is the philosophy which is used when organizing the computers, programs, etc. and all the information that flows between them.
- Another way to think of CIM is that it allows the structure of an organization to be entered into the computers.
- CIM focuses on connecting the various CAD/CAM modules.

Advantages of CAM

Fast and accurate production

Machines can run constantly on repetitive tasks

Good for producing on a mass/flow production line

Disadvantages of CAM

Expensive to set up

Needs a skilled workforce of engineers

Downtime required for maintenance

Q20) Advantage and Disadvantage of CIM

Advantage of CIM

1.CIM improves the short run responsiveness consisting of :

- Engineering changes
- Processing changes
- Machine down time or unavailability
- Operator unavailability
- Cutting tool failure
- Late material delivery

2.CIM improves long run accommodations through quicker and easier assimilation of :

- Changing product volumes
- New product additions and introductions
- Different part mixes

3.CIM reduces inventory by

- Reducing lot sizes
- Improving inventory turnovers
- Providing the planning tools for Just – in Time manufacturing

4.CIM increase machine utilization by :

- Eliminating or reducing machine setup
- Utilizing automated features to replace manual intervention to the extent possible
- Providing quick transfer devices to keep the machines in the cutting cycle.

Some quantifiable benefits achieved by apply CIM are :

- Engineering design costs can be reduced by 15 to 30 %.
- The overall lead times can be reduced by 30 to 60 %.
- The product quality can be increased dramatically, as measured by the yield of acceptable product, offering 2 to 5 times the previous level.
- Productivity of the manufacturing operations can be increased by 40 to 70 %.
- Operating time related productivity can be increased by 2 to 3 times.
- The productivity of engineers and engineering managers can be increased by 5 to 35 times, measured in terms of extent and depth of analysis in the same or less time.
- Work in process can be reduced by 30 to 60 %.

Disadvantage of CIM:

- high initial capital costs/investments due to computers, robots, training of personnel
- maintenance is complex, requires highly skilled employees

Q21) Write short notes on :

a)AGVs

b)Lean manufacturing

c)Robotics

d)Combined CNC/DNC

a)AGVs

Sometimes called self-guided vehicles or autonomous guided vehicles, automated guided vehicles (AGVs) are material handling systems or load carriers that travel autonomously throughout a warehouse, distribution center, or manufacturing facility, without an onboard operator or driver.

Benefits of AGVs

AGVs offer numerous benefits in warehousing and manufacturing.

Increase efficiency and productivity

Because they operate autonomously, AGVs increase efficiency and **productivity**, and they're predictable and reliable for repetitive tasks. AGVs eliminate unnecessary walking and also eliminate the physical labor of transporting materials. They set the pace for workers, as well, keeping associates on-task. AGVs like collaborative mobile robots guide associates through each task, reducing human error, which helps to **improve order picking accuracy** and minimize loss and misplaced products

Consistent costs

AGVs are typically acquired on a per unit or per rental period cost basis, so there's less fluctuation in costs compared to human labor, which can fluctuate based on market conditions and demand.

Flexibility

Some AGVs offer the flexibility of easily changing routes (compared to others which require re-routing guide wires or other infrastructure to adjust a vehicle's route). Automated guided vehicles are a scalable solution, as well, with the ability to add additional units based on demand.

Less space required

Compared to other automation solutions, such as conveyor systems, AGVs require less space. Some AGVs are smaller compared to traditional warehouse equipment, such as forklifts, which allows for floor layouts with narrower aisles and better space utilization.

Improved safety

Finally, AGVs are a safe automation solution for warehouses, distribution centers and manufacturing facilities. AGVs are equipped with sensors to avoid collisions. Advanced AGVs like AMRs have intelligent routing capabilities that enable them to plan the most efficient path through a warehouse or facility, reducing aisle congestion and preventing injuries.

b)Lean manufacturing

Lean manufacturing is a production process based on an ideology of maximising productivity while simultaneously minimizing waste within a manufacturing operation. The lean principle sees waste is anything that doesn't add value that the customers are willing to pay for.

Advantages of Lean Manufacturing

1. Waste Minimization

Lean manufacturing can efficiently minimize waste within a production facility. This is arguably the most significant benefit of lean manufacturing. Waste is defined by any activity that does not add value to the process. Common waste areas include: motion, inventory, waiting, overproduction, defects, transportation, and over-processing. As companies sit on large amounts of inventory and waste, this process eliminates outdated or aged inventory. In addition, this process reduces the costs within the operation.

2. Enhanced Customer Relationships

Lean focuses on loyal customers' concerns and suggestions to cut some wasteful processes. Rather than focusing on the needs of all customers, companies are able to focus on their loyal customers to build strong and reliable relationship. This way, your customer interactions will improve and the relationships with your trusted customers will offer a steady flow of revenue coming in.

3. Lean Infrastructure

A lean infrastructure means that you are only dealing with a few components: building, tools, supplies, equipment, and labor to fulfill near-term inventory demand. The facility does not waste space within the operation and enables the facility to come as close as it can to production efficiency.

Disadvantages of Lean Manufacturing

1. Equipment Failure

Lean has very little room for error. Equipment or labor failure can lead to major inconsistencies and can make the entire operation fall behind. In other mass production facilities, employees could move from one machine to another in the event of a breakdown. In lean, there are not many other places for employees to move to because everything within the operation is being utilized. In addition, the breakdown of a machine must be fixed immediately as there are usually no alternative resources that can do the work. This is why it is important to stay on top of all machine maintenance and inspections.

2. Delivery Inconsistencies

In correlation with equipment failure, lean manufacturing can lead to delivery inconsistencies. Using lean techniques means that you have a smaller error margin. If your supply deliveries are late, you may not have enough raw materials to meet your customer demands, leading to late

deliveries. This disadvantage can hinder customer relationships, push customers towards your competitors, and cost you revenue.

3. Employee Dissatisfaction

Adopting lean manufacturing processes requires change among employees to more efficient production processes to ensure that quality products are being made. This can be risky if employees reject the new methods. Having good managers that can help support and persuade the change from one technique to another can be helpful.

c)Robotics

Some manufacturers use robotics to automate repetitive, menial tasks such as material handling and assembly. Industrial robots can typically complete these tasks faster and improve repeatability and quality. Common use cases of repetitive or fixed automation include: Material handling. Pick-and-place.

In robotic processing operations, the robot manipulates a tool to perform a process on the work part. Examples of such applications include **spot welding, continuous arc welding, and spray painting**. Spot welding of automobile bodies is one of the most common applications of industrial robots in the United States.

d)Combined CNC/DNC

(82)

Advantages of DNC(1) Elimination of punched tapes & tape readers :-

DNC eliminates the punched tapes & tape readers. In some systems, hard-wired control unit is also eliminated, and replaced by a special m/c control unit (designed to be compatible with DNC operation).

(2) Greater Computational Capability & flexibility :-

- The DNC system performs the computational & data processing functions more effectively than traditional.
- Because these functions are implemented with software rather than hard-wired devices, there exists the flexibility to alter and improve the method.

(3) Convenient storage of NC part programs in computer files :- (punched tapes used in conventional NC)(4) Reporting of shop performance :-

It collects, processes and reports about the production performance data from the NC machines.

(5) Establishes the framework for the evolution of future computer-automated factory.Combined DNC/CNC Systems

- The combination of DNC & CNC provides the opportunity to add new capabilities & refine existing capabilities in these computerized manufacturing systems.
- The combination of CNC & DNC → resulted in elimination of the use of punched tape as the input media for CNC machines.

(83)

The DNC computer downloads the program directly to the CNC computer memory.

- The second advantage of combining CNC & DNC is redundancy. If the central DNC computer fails, this will not necessarily cause the individual machines in the system to be down. It is possible to provide the necessary backup to permit the CNC machines to operate on a stand-alone basis.

- * This backup capability consists of two elements. The first is a file of punched tapes which duplicate the programs contained in the DNC computer files.

- * The second is that each CNC m/c must be equipped with a tape reader for the purpose of entering the program from the punched tape.

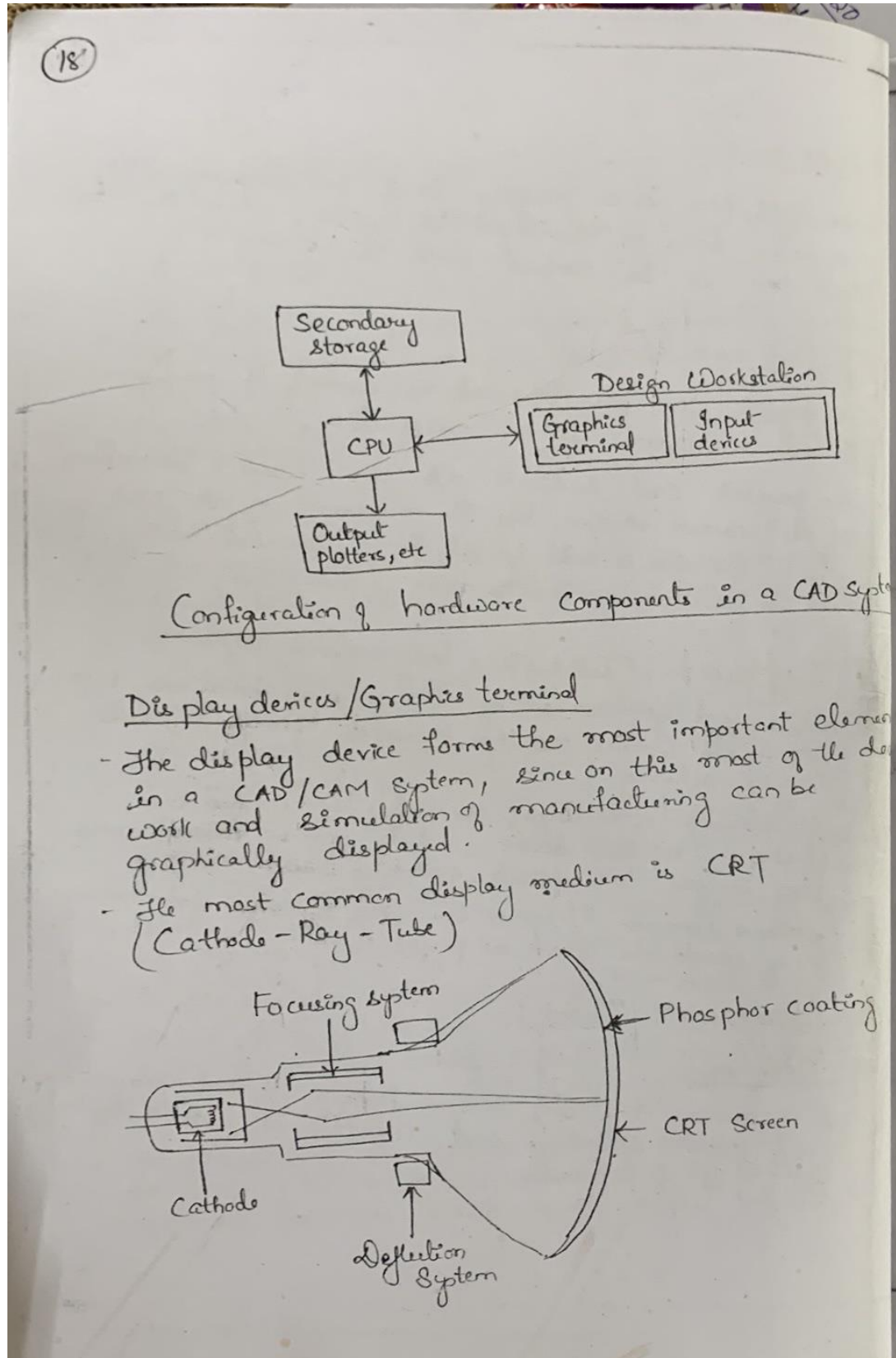
The third improvement that develops from combined DNC/CNC systems is improved communication between the central computer and the shop floor.

It is easier for computers to communicate with other computers than with hard-wired devices.

Adaptive Control Machining Systems

- For a machining operation, the term 'adaptive control' denotes a control system that measures certain output process variables and uses these to control speed/feed.
- Some of the process variables that have been used in adaptive control machining systems include spindle deflection or force, torque, cutting temp, vibration amplitude.

Q22) What are the important functions of the design workstation?



Q23) Explain the three types of coordinate systems used to input, store & display

(43)

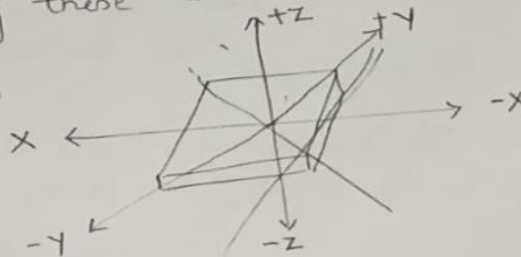
- In this way, major errors in the tape is discovered

(5) Production

- The final step in the NC procedure is to use the NC tape in production.
- The m/c tool operator loads the raw workpart in the m/c and establish the starting position of the cutting tool relative to the W/P.
- The NC System then takes over and ^{machines} ~~makes~~ the part according to the instructions on tape. When the part is completed, the operator removes it from the m/c.

NC COORDINATE SYSTEMS

- The purpose of the coordinate system is to provide a means of locating the tool in relation to the W/P.
- In order to plan the sequence of positions & movements of the cutting tool relative to the W/P, it is necessary to establish a standard axis system by which the relative positions can be specified.
- In NC m/c tool axis system for milling and drilling operations, two axes 'x' and 'y' are defined in the plane of the table. The 'z' axis is \perp to this plane and the movement in the 'z' dirⁿ is controlled by the vertical motion of the spindle.
- The +ve and -ve directions of motion of tool relative to table along these axes is shown in Figure.



(44)

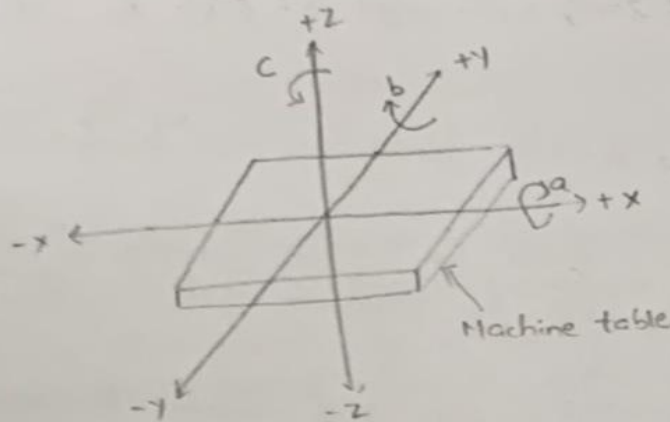
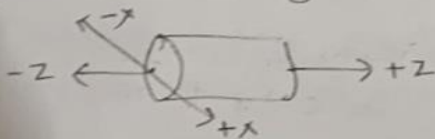


Fig.1 NC machine tool axis system for milling & drilling operations.

- In addition to the 3 linear axes, these machines possess the capacity to control one or more rotational axes.
- 3 rotational axes in NC: a, b, c axes. These axes specify angles about the x, y and z axes.
- 'Right-hand rule' is used to distinguish +ve from -ve angular motions.
(Using the right hand with the thumb pointing in the +ve linear dirⁿ, the fingers of the hand are curled to point in the +ve rotational dirⁿ)
- For turning operation, z-axis is the axis of rotation of the workpart & x-axis defines the radial location of the cutting tool.



Fixed zero and Floating zero

Fixed zero:- M/c The programmer must determine the position of the tool relative to the origin (Zero point) of the coordinate system.

Q24) Model geometry & graphics.

(27)

Functions of a graphics package

Some common function sets are:-

- 1) Generation of graphic elements
- 2) Transformations
- 3) Display control and windowing functions
- 4) Segmenting functions
- 5) User input functions

(1) Generation of graphic elements :-

- A graphic element in computer graphics is a basic image entity such as a dot, line segment, circle, etc.
- The collection of elements in the system could also include alphanumeric characters & special symbols.
- The user can construct the application model out of a collection of elements available on the system.

(2) Transformations :-

- Transformations are used to change the image on the display screen & to reposition the item in the database.
- They are applied to the graphic elements to aid the user in constructing an application model.
- These transformations include enlargement & reduction of the image by a process called 'Scaling', repositioning the image or translation and rotation.

(28)

(3) Display control and windowing functions

- It provides the user with the ability to view the image from the desired angle and at the desired magnification.
- This is sometimes referred to as windowing because the graphics screen is like a window being used to observe the graphics model.
- Another aspect of display control is hidden-line removal.

(4) Segmenting functions

- It provide users with the capability to selectively replace, delete or otherwise modify portions of the image.
- The term 'segment' refers to a particular portion of the image which has been identified for purposes of modifying it.

(5) User input functions

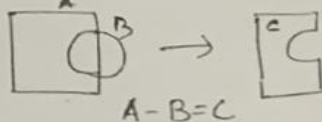
- They permit the operator to enter commands or data to the system.
- The entry is done by means of operator input devices.

Constructing the geometry

(1) The use of graphics elements

- These elements are called by the user during the construction process and added one by one to create the model.
- The graphics elements can be subtracted as well as added.

Ex:-



(29)

Rotation:-

For a +ve angle, the rotation is in the counterclockwise.
In matrix notation, the procedure is

$$(x', y') = (x, y)R$$

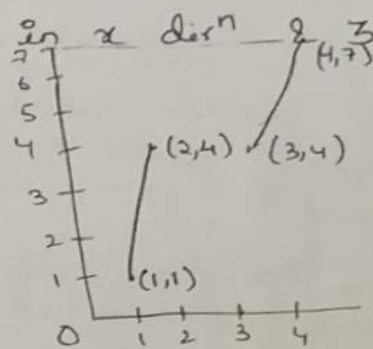
where $R = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$ the rotation matrix

Ex.1 Line is defined by
 $L = \begin{bmatrix} 1 & 1 \\ 2 & 4 \end{bmatrix}$

Translate the line by 2 units in x dirⁿ & 3 units in y dirⁿ.

$$\begin{bmatrix} 1 & 1 \\ 2 & 4 \end{bmatrix} + \begin{bmatrix} 2 & 3 \\ 2 & 3 \end{bmatrix} = \begin{bmatrix} 3 & 4 \\ 4 & 7 \end{bmatrix}$$

The new line has end points (3,4) & (4,7)



*

Ex.2

For the previous problem, apply a scaling factor of 2 line.

$$T = \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$$

$\begin{matrix} \nearrow x\text{-axis} \\ \searrow y\text{-axis} \end{matrix}$
 $\begin{matrix} \nwarrow x\text{-axis} \\ \swarrow y\text{-axis} \end{matrix}$

m-unit along x axis
n-unit " " y axis

$$\begin{bmatrix} 1 & 1 \\ 2 & 4 \end{bmatrix} \cdot \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix} = \begin{bmatrix} 2 & 2 \\ 4 & 8 \end{bmatrix}$$

Ex.3 Rotate the line about the origin by 30°

$$R = \begin{bmatrix} \cos 30 & \sin 30 \\ -\sin 30 & \cos 30 \end{bmatrix} = \begin{bmatrix} 0.866 & 0.5 \\ -0.5 & 0.866 \end{bmatrix}$$

The new line is

$$\begin{bmatrix} 1 & 1 \\ 2 & 4 \end{bmatrix} \cdot \begin{bmatrix} 0.866 & 0.5 \\ -0.5 & 0.866 \end{bmatrix} = \begin{bmatrix} 0.366 & 1.366 \\ -0.268 & 4.464 \end{bmatrix}$$

Q25) Briefly discuss the data required for Computer Assisted Part Programming(CAPP)

Here are six planning steps to complete before producing a new program in CNC.

1. Step 1: Determine the machining operations to be performed. ...
2. Step 2: Decide the machining order. ...
3. Step 3: Do the math. ...
4. Step 4: Consider the workholding device. ...
5. Step 5: Consider the cutting tools.
6. Step 6: Write the documentation.

Q26) Explain the NC motion control system

(46)

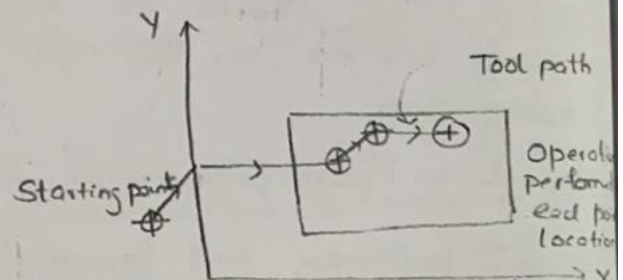
NC MOTION CONTROL SYSTEMS

- In order to do the machining process, the cutting tool and workpiece must be moved relative to each other.
- In NC, there are 3 basic types of motion control:
 - 1) Point-to-point (PTP)
 - 2) Straight cut
 - 3) Contouring

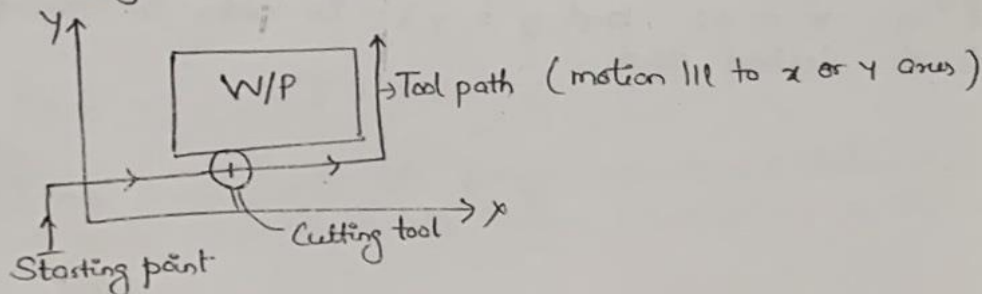
Point-to-point NC

- Also called 'Positioning System'.
- The objective is to move the cutting tool to a predefined location.
- The path or speed by this movement is done is not important in PTP.
- Once the tool reaches the desired location, the machining operation is performed at that position.

Ex:- NC drill press.

Straight-cut NC

- Straight-cut control systems are capable of moving the cutting tool parallel to one of the major axes at a controllable rate.
- It is appropriate for milling operations to fabricate workpieces with rectangular configurations.



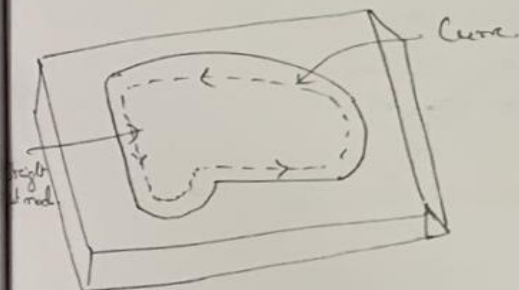
(47)

Contouring NC

- Contouring is the most complex, the most flexible and the most expensive type of m/c tool control.
- Capable of performing both PTP and straight-cut operations.
- Capable of controlling more than one axis movement of the m/c tool.
- The path of the cutter is continuously controlled to generate the desired geometry of the workpiece.

(Thus called Continuous-path NC System)

- Straight or plane surfaces at any orientation, circular paths, conical shapes or any mathematically definable form are possible under contouring control.
- In order to machine a curved path in NC contouring system, the dirⁿ of the feed rate must continuously be changed so as to follow the path.
- This is accomplished by breaking the curved path into very short straight-line segments that approximate the curve. Then the tool is commanded to machine each segment in succession.

Applications of NC :-

- Milling
- Drilling
- Turning
- Grinding
- Sawing
- Boring

Q27) Describe the various database models which are generally used

(33)

Data base structure

- The CAD data-base contains the application models, drawings, assemblies, etc.
- The data base resides in computer memory (primary & secondary storage).

The basic ingredients of the application model :-

- (1) Basic graphic elements (points & other elements)
- (2) Geometry (Shape) of the model components & their loc in space.
- (3) Topology or structure of the models - how the various components are connected to form the model.
- (4) Application-specific data, such as material properties
- (5) Application-specific analysis programs, such as finite element analysis programs.

- The list represents a building-block approach to model formulation. The model structure consists of both data and procedures to connect, describe and analyze the model.

- One possible data structure involves storing the coordinates of geometry, together with other information which might be required to completely define the model.

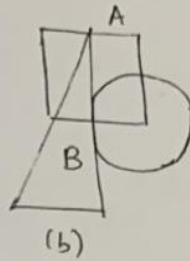
There are disadvantages to this type of data structure.

Ex:- Let us consider a cylinder. It consists of a line segment parallel to the y-axis & rotated about that axis to form a cylinder. (We require line segment (points) & axis of rotation)

→ We have to find solid cylinder.

- Boolean operations can be used to construct the geometric model.

(34)



- The solid model in part (a) of the figure is formed by the intersection of the complement of the cylinder C with the union of rectangular solid A and triangular prism B.

$$\overline{C}(A+B)$$

- Part (b) of the figure shows the three elements A, B & C in cross-sectional view.

WIRE-FRAME VERSUS SOLID MODELING

- In the construction of the wire-frame model, the edges of the objects are shown as lines.
- For objects in which there are curved surfaces, contour lines can be added, to indicate the contour.
- The image assumes the appearance of a frame constructed out of wire - hence the name 'Wire frame' model.
- Wire-frame models are quite adequate for 2-dimensional representation.
- Many 3-dimensional wire-frame systems do not possess an automatic hidden-line removal feature. Consequently, the lines that indicate the edges at the rear of the model are seen, which can cause the image to be somewhat confusing to the viewer.
- Another limitation:- CAD systems define the model in their databases. Ex:- There may be doubt in case of a surface definition as to which side of the surface is solid.

Q28) Define DNC & Explain in detail its different functions.

(76)

Advantages of CNC

- (7 marks)
- (1) The part program tape & tape reader are used only once to enter the program into computer memory.
 - (2) Tape editing at the m/c site:-
(change of tool path, speeds & feeds) at the site of m/c tool.
 - (3) Metric conversion:- CNC can accommodate conversion tapes prepared in units of inches into the International System of units.
 - (4) Greater Flexibility:-
provides opportunity to introduce new control options with relative ease at low cost.

(8)

Direct Numerical Control

- Manufacturing system in which a no. of machines are controlled by a computer through direct connection & in real-time.
- The tape reader is omitted in DNC, thus relieving the system of its least reliable component.
- The part program is transmitted to the m/c tool directly from the computer memory.
- The DNC computer is designed to provide instructions to each m/c tool on demand. DNC also involves data collection & processing from the m/c tool back to the computer.

(80)

Functions of DNC

- (1) NC without punched tape
- (2) NC part program storage
- (3) Data collection, processing & reporting
- (4) Communications

NC without punched tape :-

- Several of the problems with conventional NC are related to the use of punched tape (unreliable tape reader, paper tape, difficulties in making corrections & changes in the program contained on punched tape, etc)
- There is also the expense associated with the equipment that produces the punched tape.
(So it is eliminated)

(2) NC part program storage :-

- A second important funⁿ of the DNC system is concerned with storing the part programs.
- First, the programs must be available for downloading to the NC m/c tools.
- Second, the subsystem must allow for new programs to be entered, old programs to be deleted and existing programs to be edited as the need arises.
- Third, DNC software must accomplish the postprocessing function.
- Fourth, the storage subsystem must be structured to perform data processing & management functions such as file security, display of programs, manipulation & etc.

(81)

DNC program storage subsystem consists of an active storage & a secondary storage.

Active storage used to store NC programs which are frequently used. The active storage can be readily accessed by the DNC computer to drive an NC m/c in production.

Secondary storage could be used for NC programs which are not frequently used.

Ex:- Magnetic tape, floppy disks, punched tape.

3) Data Collection, processing & reporting

- DNC involves the transfer of data from the m/c tools back to the Central Computer. DNC involves a two-way transfer of data.

- The basic purpose is to monitor production.

4) Communications :-

- A communications network is required to accomplish the previous 3 functions of DNC.

- Communication among the various subsystem is a function that is central to the operation of any DNC system.

- The essential communication links in DNC are between the following components of the system.

Central Computer & m/c tools

Central Computer & NC part programmer terminals

Central Computer & bulk memory, which stores the NC programs.

Q29) Discuss about the reasons for implementing a CAD system.

- Increases Productivity. ...
- Higher Quality Designs. ...
- Reuse and Easily Change Designs. ...
- Easier to Read. ...
- Simplified Sharing. ...
- Documenting the Design. ...
- Skill of the Designer. ...
- Designing Physical Objects in a Virtual Workspace.